

along selected ecoclimatic transects reveal moisture, soil, and land-use controls on gradients of ecosystem production and soil trace-gas emissions (carbon dioxide ( $\text{CO}_2$ ), nitrogen dioxide ( $\text{N}_2\text{O}$ ), and nitric oxide ( $\text{NO}$ )).

Building upon this research, ecosystem scientists at Ames Research Center have been selected for the

NASA Science Team component of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia.

**Point of Contact: C. Potter**  
(650) 604-6164  
cpotter@mail.arc.nasa.gov

## Ultraviolet Radiation Effects on Carbon Isotope Fractionation

Lynn Rothschild, David DesMarais, Anne Tharpe

The objective of this project is to determine if ultraviolet (UV) radiation affects stable carbon isotope ratios. If so, is there an ecologic (e.g., microbial mat vs. phytoplankton) or taxonomic (e.g., prokaryote vs. eukaryote, alga vs. plant) correlation with the effect? These data will provide the basis for presenting the phenomenon to the scientific community, for estimating how widespread the phenomenon is, and for suggesting ways to begin to elucidate the mechanisms underlying the effect. Ultimately this work could lead to a re-interpretation of isotopic ratio studies, including a re-interpretation of the fossil record.

Isotopic measurements and, more specifically, ratios of  $^{13}\text{C}$  to  $^{12}\text{C}$  (isotopes of carbon) in organic relative to inorganic matter, play an important role in interpreting biological activity. In the interpretation of the fossil record, stable carbon isotope ratios are one of the most critical sources of data next to morphological fossils. They are a possible approach to searching for life on Mars. Stable carbon isotope ratios are playing an increasingly important role in the analysis of global carbon fluxes, of biogeochemical features of modern ecosystems, and of community structure. They have even been used to determine diet in archeological studies.

The stable carbon isotopic composition ( $\delta^{13}\text{C}$ ) of a plant or photosynthetic microorganism growing on carbon dioxide ( $\text{CO}_2$ ) is determined principally by the isotopic composition of the  $\text{CO}_2$  as well as by any isotopic discrimination associated with  $\text{CO}_2$  uptake. Bulk isotopic composition can be further modified somewhat by enzymatic discrimination during the biosynthesis of amino acids, lipids, and nucleotides, and during respiration. To the extent that

UV irradiation alters the patterns of carbon flow in an organism, it can also alter isotopic composition.

An experiment was conducted to determine if UV could affect stable carbon isotope ratios in algal communities. Screens were set up that were UV-transparent or that filtered out UVA or UVA+UVB, over two types of microbial ecosystems in Yellowstone National Park; one dominated by the red alga *Cyanidium* sp., and one dominated by the green alga *Zygogonium* sp. After 90 days of the treatments, the samples were collected, frozen, and turned over to DesMarais' laboratory for analysis. The results (first figure) are clear: In these two mats, UV radiation does affect the carbon isotopic signature.

Experiments were then conducted on radishes to examine UV effects on isotope fractionation. Radish seeds were grown in flats on the roof of the laboratory under different types of UV screening, with approximately 50 plants germinating per treatment. The plants were rotated periodically and were grown

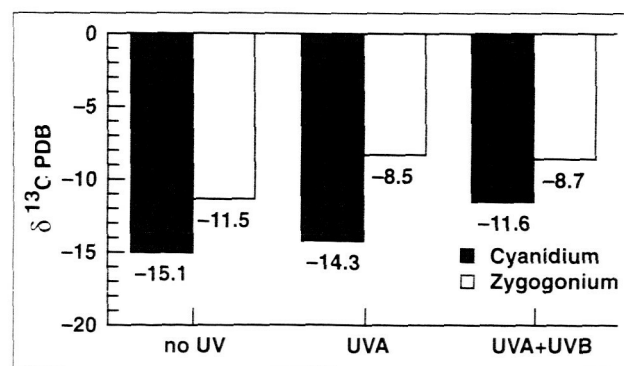


Fig. 1. Carbon isotope values for red and green algae grown under three different UV treatments.

near a blower that controlled temperature. Isotopic analysis of leaf tissue, which at the site of photosynthesis should be the most sensitive to isotopic shifts, showed no difference among the three UV treatments: full solar UV+PAR (photosynthetically active radiation, 400–700 nanometers), –UVB, and –UVA+UVB (second figure). Unlike the microbial mats, in which the absence of UV led to a depletion of  $^{13}\text{C}$  relative to  $^{12}\text{C}$  of several per mil, there was no detectable difference among plant treatments.

Isotopic discrimination in plant leaves is largest when the rate at which  $\text{CO}_2$  is supplied to the enzyme ribulose biphosphate carboxylase (RubisCO) exceeds the enzymatic uptake rate. Discrimination is suppressed to the extent that  $\text{CO}_2$  fixation draws down the  $\text{CO}_2$  concentration inside the leaves because of leaf stomatal resistance. The  $\delta^{13}\text{C}$  values of the radish plants were identical under all growth conditions. This indicates that the balance between the rates of  $\text{CO}_2$  diffusion through the leaf stomata and  $\text{CO}_2$  fixation by RubisCO were unchanged under the three UV irradiation regimes.

In contrast, the  $\delta^{13}\text{C}$  values of the microorganisms did increase with higher levels of UV exposure. This trend cannot be attributed to slower rates of photosynthesis at higher UV exposures, because  $\delta^{13}\text{C}$  values would be expected to decrease with a decrease in the rate of photosynthetic  $\text{CO}_2$  assimilation, relative to the rate of  $\text{CO}_2$  supply to the microbes. This isotopic trend compels another

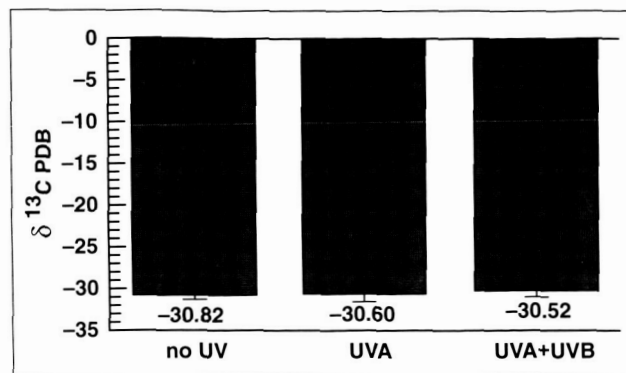


Fig. 2. Isotopic fractionation for radishes.

interpretation that invokes changes in carbon flows elsewhere in metabolism, related perhaps to the synthesis of nucleotides, proteins, or lipids, or to respiration. If the influence of UV on isotopic discrimination in metabolism could be understood, it might allow us to delineate more precisely the metabolic effects of UV irradiation.

The conclusion is that UV can effect isotope fractionation in some, but not all photosynthetic organisms. Aruna Balakrishnan, a student, collaborated with the Ames researchers on this project.

**Point of Contact: L. Rothschild**  
 (650) 604-6525  
[lrothschild@mail.arc.nasa.gov](mailto:lrothschild@mail.arc.nasa.gov)

## Perceptual Image-Compression Prototype

Andrew B. Watson

NASA missions have generated and will continue to generate immense quantities of image data. For example, the Earth Observing System is expected to generate data in excess of one terabyte per day. NASA confronts a major technical challenge in managing this great flow of imagery: in collection, preprocessing, transmission to Earth, archiving, and distribution to scientists at remote locations. Expected requirements in most of these areas clearly exceed the capabilities of current technology. Part of the solution to this problem lies in efficient image-compression techniques. As part of a larger program of human factors research, Ames has developed a

new technology called DCTune to improve image compression.

For much of this imagery, the ultimate consumer is the human eye. In this case, image compression should be designed to match the visual capacities of the human observer. DCTune is based on a model of human vision, and DCTune technology is compatible with JPEG (Joint Photographic Experts Group), the current international standard for still-image compression. Two patents have been awarded for DCTune technology.